Shore Profiles:

A field exercise examining beach topography and coastal processes

Grade Level

8th – 12th

Objectives

* To provide high school students with an inquiry-based learning experience.

* To increase public awareness & understanding of coastal processes & hazards.

* To obtain a better understanding of the relationship between coastal processes, beach morphology, and shoreline change.

N.C. Standard Course of Study

Grade 6
(6.E.2.4)

Earth & Envir. Sci.
(EEn.2.4.2, EEn.2.6.4, EEn.2.7.3)

Extension – Biology
(Bio.2.1.3, Bio.2.1.4, Bio.2.2.1, Bio.2.2.2, Bio.3.5.1)

Overview:

Working in teams, students conduct **topographic** surveys (beach profiles) using a pair of Emery rods (profile poles), a metric tape, and a sight level to accurately survey a shore from the **foredunes** to the waterline. Students also measure wind speed and direction, estimate the width of the surf zone, and observe the breaker type. They note the wave direction, height and period, and estimate the **longshore** current speed and direction using a float, stop watch, and tape measure. If time permits students can also quantify the vegetation present along the profile and collect sediment samples for laboratory analyses. Back in the classroom, students analyze their data and look for relationships among the observed phenomenon.

Preparation for Field Work:

When planning a date for your beach surveys you should first check the tide tables and schedule your field trip to coincide with low tide. Two days prior to your scheduled field trip you should check the weather forecast and gather your sampling gear together (use equipment checklist below).

Materials:

Beach profile equipment list

1. Emery rods or long wooden poles marked in centimeter increments (profile poles)
2. Tape measure (in meters)
3. Sighting compass
4. Sighting level (can be purchased at a local hardware store - $14.95)
5. Small metal survey flags or wooden stakes
6. Clipboard
7. Data forms and pencils/pens

Process measurement equipment

1. Sighting compass
2. Wind gauge (Dwyer Air Meter, Model 460 - $29.00)
3. Stopwatch
4. 3 floats (rubber/plastic balls that one can throw at least 30 m)

Background:

A beach is a geological landform consisting of loose rock particles such as sand, gravel, pebbles, and cobble combined with lots of shell fragments. The beach sediments are in constant motion due to winds, tides, and storm activity, as well as disturbance by humans (off-road vehicles and beach nourishment activities). A typical sandy beach is composed of three general areas: a beach face, a **berm crest**, and a dune formation. The beach face is the area from the water's edge to the berm crest (also known as the intertidal zone). A berm crest is the highest area on the beach that waves carry and deposit sand. Dunes are formed when sand is carried by the wind from the beach face and deposited on the landward margin above the berm crest. Dunes are stabilized and built higher by grasses and other plants that trap wind blown sand.

When a wave hits a beach, the water in the wave rushes up the beach as far as it can until its energy is **dissipated**. Once there is no more energy to carry the water any further up the beach, the water simply falls back down the beach towards the ocean and in the process it deposits sand, sediment and debris on the beach face. As the water **recedes** off the beach face, additional sediment particles are picked up and carried with the water back to the sea. Although sediments are constantly moving on the beach, a balance generally exists between deposition and removal. Sometimes things happen to upset that natural balance.

During the winter strong storms are common along the coast and beaches generally erode. This is because storms produce waves that are much stronger and more destructive than normal. The force of storm waves removes significantly more beach sediments than they leave. In the summertime, waves are calmer and thus more sediments are deposited than are removed so the beach builds up during these months. Again, an overall balance is maintained over time between removal (in the winter) and deposition (in the summer) of sediments on the beach. Severe storms, such as hurricanes, do the most damage to beaches. They often change the shape and area of the beach entirely. Hurricanes can even level dunes, which stand as the last line of defense to protect the land behind them. Without the dunes to stop the water, waves carry water over roads and into beach houses, sometimes destroying everything in their path.

A profile is made of the beach to monitor how beaches change over time. Some changes are minor and go unnoticed. Others are major and result in a totally new beach profile. In this activity you will make a beach profile by surveying the beach and recording changes in elevation. After you come back to class, you will examine your data and plot your shore profile. After collecting your profile measurements, you will measure wind speed and direction, estimate the width of the surf zone, and observe the breaker type. You will also note the wave direction, height and period, and estimate the longshore current speed and direction using a float, stop watch, and tape measure. These process measurements help us understand why the beach changes.

Activity:

Initial Site Reconnaissance

Prior to beginning your shore profile take a short walk along the beach and make **qualitative** observations about the shape of the beach and identify prominent beach features including the foredune, vegetation line, wrack line, berm crests and the shiny zone. Taking time to walk the beach without the worry of having to take an accurate measurement will help you interpret the **quantitative** data you collect while conducting your shore profile. Do a little beach combing and see if there are any prominent or unusual items such as dead fish or seaweed on the beach. Note how the beach has changed since your last visit. Does it appear to have **eroded** or **accreted**? Have there been human alterations?

Part I: Beach Profile Measurement

A beach profile is a topographic **transect** measured **perpendicular** to the shoreline. Taking several shore profiles through time allows us to examine shoreline erosion and accretion trends and provides us with a means for assessing beach recovery after a storm.

You will measure beach profiles using the Emery technique, named after the person who applied this topographic measurement method to beach studies. It is simple and "low-tech" but accurate. A very important note of caution, however, is required. If a measurement error is made at one point, then all subsequent points along the profile will be offset by that amount of error. Therefore, take your time and double check each reading. It is very disappointing to realize after returning from the field that your hard-earned data are erroneous.

1. ***Mark profile with stakes or flags*** – Delineating the transect line prior to making measurements will ensure that the shore profile is done in a straight line that is perpendicular to the shoreline.

    a. One person goes to the foredune crest or other point from which the entire profile is in view. Using a sighting compass, sight back to the **datum** (landward start of the profile – should be a GPS point if possible) and move left or right until the correct azimuth is obtained (when sighting landward, the **azimuth** will actually be the reciprocal (180 degrees difference) of the value listed as the azimuth). Place a stake or flag at this location. Make sure your transect is perpendicular to the land/water interface. The purpose of this step is to delineate a straight line. If you sight back to your starting point and then turn 180 degrees the other direction (now facing the water) and you are not perpendicular to the water then you need to adjust yourself (moving left or right) so that the line you delineate is perpendicular to the water.

    b. Standing on this point, have a team member with a stake or flag move about half way between you and the datum point. Line this person up so that they are on the profile (between you and the datum point). Have them place another stake or flag. The landward portion of the profile is now marked.

    c. Still standing on the same point determined in (a), turn 180 degrees and, with the compass, site toward the water in the direction of the proper azimuth for the profile. Have a team member go to the wet/dry line (The wet/dry line is the landward most limit of sand wetted by ocean water, not rain). Direct the team member to move left or right until they are on the profile. Have them place a stake or flag at this point.

d. Now have the team member move toward you along the profile. Line them up on the profile. Have them place a stake or flag at the vegetation line (seaward extent of vegetation).

e. Place other flags along the profile at all berm crests, the last high-tide swash line (often delineated by a line of debris or wet/dry boundary), edges of beach roads, and other features you want to be sure you measure during the profile survey.

Note: If one can view the entire profile from the water's edge, fewer stakes will be required. This will be the case when surveying a profile without a prominent foredune. The idea is to place markers so that at least 2 of them are visible behind or in front of the surveyors when conducting the topographic survey.

2. **Conduct topographic survey (profile)** - After marking the profile line, you are ready to measure distances and heights along the profile. At least three people are needed for this task: one person will be the data recorder; one person will hold the upper rod and use the sight level to read the lower rod; and one person will hold the lower (seaward) rod and determine the horizontal distance between data points.

a. Start at the datum point. The two individuals holding the profile poles should stand 3-5 meters apart on the transect line with the person holding the upper pole standing on the datum point and the person holding the lower pole 3-5 meters seaward. The individual holding the upper pole will use the sight level (Fig. 1) to determine the change in elevation from their location to the location of the lower pole. The data recorder will record the eyelevel of the upper pole person (height at which the sight level was used) and the location on the seaward (lower) pole where the crosshairs of the sight level intersect with the pole on the data sheet (Appendix I). The horizontal distance (in meters) will also be measured and recorded.

Figure 1. Sight level for determining change in beach elevation.

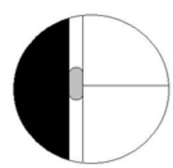

Figure 2. View through the sight level. When the bubble is in the center the view is level and the seaward profile pole should be read.

Note - The maximum distance between the rods should be about 5 meters. Shorter distances should be measured where there is a change in the slope of the ground or some other key topographic feature such as a berm crest.

b. Once all data for the first point has been collected the individual holding the upper pole will move to the lower pole location and take hold of the lower pole (without moving it). The lower pole becomes the upper pole and the upper pole is moved 3-5 meters seaward. Make sure that you remain on the transect. The procedure is repeated until the survey crew reaches the waterline. All data should be recorded on the data sheet. Once back in the classroom the data can be used to graph the beach profile. If the beach is surveyed multiple times then the multiple profiles can be used to assess topographic changes either temporally or spatially.

Student holding wooden profile pole.

Student using sight level to determine vertical (elevation) change.

Students measuring the horizontal distance with metric tape measure.

Part II: Process Measurements

Tracking the topography of the beach shows us how the beach changes, but measuring the wind and waves will help us to understand why the beach changes. The process measurements you make during your beach visits are just a snapshot of what is going on in terms of wind, waves, and currents. What is really pertinent to the state in which you find the beach, however, is what was happening for some period of time (hours to months) before your arrival. Unless you obtained process measurements every day, you will not be able to collect enough data to properly relate your measurements to your beach profiles. Fortunately there are many areas where instruments are acquiring hourly data on wind and waves.

The National Oceanic and Atmospheric Administration (NOAA) operates weather, current, and wave stations around the U.S. coast. These stations, however, will not likely be at your beach profile location, but you can use the measurements you make to determine the differences in measurements between your location and the continuously operated stations. After you have enough simultaneous measurements, you will be able to "calibrate" the continuous data for your beach location. For example, if your wave height measurements are consistently higher than those obtained by an offshore gauge you will know to increase the wave height measurements at the offshore gauge before applying the data to your beach location. Similarly if the wind direction at a weather station is consistently more out of the north than at your location or the speed is higher, then you know how to correct these data for your location.

There is another reason to make careful measurements of the processes. This is simply to hone your powers of observation and to increase your appreciation of the physical processes shaping the beach environment. The techniques here are qualitative; therefore, 3 people will make estimates to provide more reliable data. The process measurement data will be recorded attached data sheet (Appendix II).

1. ***Wind Direction and Speed***

    a. Go to a high point in the area of the beach profiles. The foredune crest or on top of a seawall would do fine. Make sure you are not shielded from the wind in any direction.

    b. Face directly into the wind by feeling it on your face. Without moving your head, raise the sighting compass and determine the bearing pointing into the wind. Record this magnetic bearing.

    c. Face directly into the wind and hold the wind meter to the wind. Hold the meter upright with the two holes on the bottom directly into the wind. Read the level at which the ball is suspended. If the ball is at the top, place your forefinger over the top hole and read from the high-range scale. Maneuver the meter so that the highest readings are obtained. This is how you know if you have it pointed directly into the wind.

    d. Watch the meter for about 1 minute and determine the sustained wind speed. The sustained wind speed does not include sudden gusts or short calm periods of wind.

    e. Determine and record the highest wind gust speed during this time.

2. ***Wave Direction***

    a. From the same point that you determined the wind direction and speed, now determine the direction from which the waves are coming.

    b. Look across the breaker zone and focus on the waves where they first break. Turn your head so that you are looking directly into the oncoming waves. Raise your sighting compass and determine the bearing directly into the waves. Record this magnetic bearing. When sighting on the breakers, you may find it helpful to align the horizontal edge of the compass so that it is parallel to the breaker line.

    c. It is important to focus on the waves where they first break offshore and not on the waves near the beach.

    d. Keep your wave direction measurement secret and pass the sighting compass to the second and then the third observer for their determinations.

    e. All observers should record their observation in the place that corresponds with their observer number as written on the top of the form.

3. ***Wave Breaking Height***

    a. Move to the waterline and estimate the height of the breaking waves when they first break offshore. Moving to the waterline gives you a better perspective for estimating height. You will be nearly on the same level of the waves.

    b. Record your estimate in centimeters on the data form. Be sure to record in the location that corresponds with your observer number at the top of the data form.

    c. Keep your estimate secret and pass the form to the next observer.

4. ***Wave Period***

    a. Focus on an imaginary point in the middle of the surf zone. You will count the waves passing this unmoving point for 10 seconds.

    b. As the crest of a wave passes your point count that as zero and start your stopwatch. The next wave is wave number one.

    c. When the 10th wave passes your point, stop the watch.

    d. Divide the number of seconds by 10 to get the wave period. Don't forget to convert minutes of time to seconds before you divide.

    e. Record your estimate in seconds on the data form. Be sure to record in the location that corresponds with your observer number at the top of the data form.

    f. Keep your estimate secret and pass the form to the next observer.

5. ***Surf Zone Width***

    a. While standing at the waterline, estimate the width of the surf zone. This is the distance from the waterline out to where the waves first break. Record your estimate in meters on the data form. As with the period and height measurements, be sure to record in the location that corresponds with your observer number at the top of the data form. You should also consider that most people tend to underestimate distances across water.

    b. Keep your estimate secret and pass the form to the next observer.

6. ***Number of Longshore Bars***

    a. Estimate the number of apparent longshore bars by counting the number of breaker lines or visible shallow zones oriented parallel to the beach. As with the period and height measurements, be sure to record in the location that corresponds with your observer number at the top of the data form.

    b. Keep your estimate secret and pass the form to the next observer.

7. ***Wave Breaker Type*** - Waves break in different ways depending on the wavelength, wave height, and slope of the surf zone. When the crest of waves curl and suddenly collapse, they are said to be "plunging". These are the types of waves surfers crave. When the crest continuously breaks as the wave moves on shore, it is said to be spilling. Surging waves push up the shore and slosh onto the beach without an orderly breaking of the crest.

    a. Observe the outer most breakers and record the breaker type as plunging, spilling, or surging. Make sure you record the outer most breaker type. Along shorelines with nearshore bars, spilling type breakers will almost always be present inshore of the outer breakers so don't confuse these breakers with what is occurring where the waves first break. There is often a mixture of plunging and spilling types, but you must decide which is the dominant type and check only one on the form.

8. ***Longshore Current*** - The longshore current is the movement of water along the shoreline and is caused by (1) waves approaching at an angle to the shoreline, (2) tidal

currents, and (3) wind. You will measure the speed and direction of the current using a float that you throw into the surf zone.

a. You need a float that you can throw at least 30 m and that has a low profile to the wind when it is in the water. A low profile is important because our intent is to measure the water current, not the wind direction and speed. A rubber or hard plastic ball about the size of a baseball and that has some weight to it makes a good float. You also need a stopwatch.

b. Go to the water line and throw the float into the middle of the surf zone or as far as you can if you can not reach the mid surf zone.

c. Step back up the beach and, with your heel, mark a line in the sand at the position of the ball and start the stopwatch.

d. Walk along the beach following the ball as it moves along the shore. Do not take your eyes off the ball. When 50 seconds have passed, mark another line in the sand.

e. Record the distance from the waterline you initially threw the float. This is useful information because your results may vary with this distance.

f. Measure in meters the distance the ball moved along the beach.

g. Multiplying the distance by 2 gives the speed of the longshore current in centimeters per second. Record the speed and direction the float moved on the form.

h. Repeat (b) through (g) two more times.

i. Make sure to retrieve your float. If the water is too cold to retrieve your float you can use oranges to determine the longshore current. Oranges are about the same size as a rubber ball, they float and they are also biodegradable.

Extension:

- This same technique can be used to delineate a salt marsh. A typical profile would extend from the upland vegetation line to the seaward edge of the lower marsh.

- In addition to examining elevational changes in the marsh or dune system, quantification of vegetation can be added to the exercise so that students learn the different plant species found in these habitats and their zonation patterns in relation to the amount of salt water exposure. Students can hone their observational and taxonomic identification skills through plant identification. Quantification of vegetation via quadrat sampling (either ¼ m^2 or ½ m^2 quadrat made from PVC pipe) provides the students with additional data to analyze and allows them to draw conclusions about elevational changes and plant community composition.

- Sediment samples can also be collected along the transect at the foredune, berm crest, and beach face. The samples can be sieved, weighed for grain size fractions and inspected using a microscope. Geologic setting and physical and biological processes control sediment grain size and type. Geologic setting refers to the geomorphology of the terrain and the type of sediment or rock on which the beach is formed. Physical processes refer to the action of waves, tides, and wind as they move sediment on the beach. Biological processes are those associated with plants and animals. Plants and animals may be sediment producers for the beach, especially shell producing animals, but they also affect sediments by their burrowing and their baffling of wind and wave energy. Grain size and type analyses will typically reveal the different processes at work. Comparison of samples over time and among different beaches will provide additional insight to how beaches respond to varying conditions.

Vocabulary:

- accretion
- azimuth
- berm crest
- datum
- dissipate
- erosion
- foredune
- longshore
- perpendicular
- recedes
- qualitative
- quantitative
- topography
- transect

Reference:

This exercise was adapted from the Texas High School Coastal Monitoring Program developed by the Jackson School of Geoscience at the University of Texas at Austin. (http://coastal.beg.utexas.edu/thscmp/index.html)
and the
University of Rhode Island, Office of Marine Programs – Discovery of Estuarine Environments, Beach Profile Field Activity.
http://omp.gso.uri.edu/doee/teacher/pdf/act23.pdf

National Science Standards:

Content Standards	*Science as inquiry. [5-8 & 9-12]*
	Science in personal and social perspective. [5-8 & 9-12]
	History and nature of science. [5-8 & 9-12]

Ocean Literacy Principles:

Essential Principle #2.	*The ocean and life in the ocean shape the features of the Earth (Fundamental Concepts - c,d,e)*
Essential Principle #5.	*The ocean supports a great diversity of life and ecosystems. (Fundamental Concept - h)*
Essential Principle #6	*The ocean and humans are inextricably interconnected. (Fundamental Concept – f)*

Appendix I
Shore Profile Data Sheet

Site : ____________________ **Date:** ____________________ **Time:** __________________

LOWER POLE MEASUREMENT (cm)	UPPER POLE MEASUREMENT (cm)	VERTICAL DISTANCE = L-U (cm)	HORIZONTAL DISTANCE (m)

Appendix II
Process Measurements Data Sheet

Site : ____________________ **Date:** ____________________ **Time:** __________________

	OBSERVER #1	OBSERVER #2	OBSERVER #3
WIND DIRECTION (compass reading)			
SUSTAINED WIND SPEED (ft/min)			
HIGHEST WIND GUST SPEED (ft/min)			
WAVE DIRECTION (compass reading)			
WAVE BREAKING HEIGHT (cm)			
WAVE PERIOD (# waves/sec)			
SURF ZONE WIDTH (m)			
# of LONGSHORE BARS			
WAVE BREAKER TYPE (circle one)	Plunging Spilling Surging	Plunging Spilling Surging	Plunging Spilling Surging
LONGSHORE CURRENT (cm/sec)			

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